VALUE OF α_s AND HIGH TWISTS FROM COMBINED ANALYSIS OF $e-\mu$ DIS DATA

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We perform a NLO QCD analysis of the combined SLAC-BCDMS-NMC-E665-H1-ZEUS data on inclusive deep inelastic cross section. Particular attention was paid to the extraction of strong coupling constant α_s and high twist (HT) contribution to the structure functions F_2 and F_L. It was shown that at small and moderate x there is a visible dependence of the extracted values of HT contribution to F_2 on the QCD renormalization scale, which indicates that in this region extracted HT can absorb NNLO QCD corrections. At larger x the dependence of HT on the renormalization scale is negligible and the influence of NNLO correction on their values should be less significant. The value of $\alpha_s(M_Z)=0.1159\pm0.0031$ (total) is obtained, where the error includes statistical, systematical and theoretical uncertainties.

The problem of strong coupling constant determination from charged leptons deep inelastic scattering (DIS) data was widely discussed recent years. These data are very precise (at the level of $O(1\%)$) and the theoretical uncertainties of the analysis are relatively small, which allows for to determine the value of $\alpha_s(M_Z)$ with the precision of $O(0.001)$. At the same time there is statistically significant discrepancy between the value of α_s obtained in the analysis [1] of combined SLAC-BCDMS proton-deuterium data [2,3] and the results of experiments performed at LEP [4]. This discrepancy can be considered as an indication on new physics beyond Standard Model [5]. Meanwhile, as it became clear in the earliest QCD analysis of DIS data the value of α_s is strongly correlated with the value of possible high twist (HT) contribution to the structure function F_2 [6]. This correlation makes the separation of log-like and power-like contributions to the scaling violation unstable with respect to various assumptions made in the analysis. In particular, as it was shown recently [7], the results of nonsinglet SLAC-BCDMS proton-deuterium data analysis are sensitive to the procedures used to handle systematic errors on the data. The central value of $\alpha_s(M_Z)=0.1180\pm0.0017$ (stat.+syst.), as obtained in the analysis of Ref.[7] with the complete account of point-to-point correlations due to systematic errors, is significantly larger than the results of Ref.[1] and is compatible with the LEP measurements and world average. In the extended version of this analysis with addition of the NMC proton-deuterium data [8] and account of HT contribution to the structure function F_L the value of $\alpha_s(M_Z)=0.1170\pm0.0021$ (stat.+syst.) was obtained [9]. In this talk we describe the effect of further extension of the analysed data set on the value of $\alpha_s(M_Z)$.

The analysis was performed in NLO QCD approximation with fixed number of evolved fermion distributions ($N_f=3$); momentum sum rule (MSR) and fermion sum rule for valence quarks were used to decrease the number of fitted parameters; HT contributions to the structure functions F_2 and F_L were parametrized in additive form; target mass correction [10] was accounted for in the fitted cross section formula; account of systematic errors was performed through the

covariance matrix approach. More detailed description of the ansatz can be found in the earlier papers [7,9,11]. The milestone results are given in Table 1. From the top to bottom rows the precision and reliability of the α_s improves due to more data included in the analysis and more corrections applied. The cut $Q^2 > 2.5$ GeV^2 was imposed because without this cut the total error is dominated by the uncertainty in QCD renormalization scale (see fourth row of Table 1) and it is meaningless to suppress the experimental error with a risk to encounter an unexpected small Q^2 effects. Our final value of $\alpha_s(M_Z)$ is given in the last row of Table 1 and its various theoretical uncertainties – in Table 2. With the account of the shifts due to this uncertainties one can obtain

$$\alpha_s(M_Z) = 0.1159 \pm 0.0031(\text{total}),$$

that is compatible with world average. In the analysis of Ref.[17] it was obtained, that in the QCD fit to the world DIS data, performed without low Q^2 cut, MSR is violated. In order to check this conclusion a test fit without imposing MSR boundary condition was made. Obtained value of total momentum carried by partons is $< x >= 0.982 \pm 0.028$ that is compatible with 1 within errors and is in disagreement with the results of Ref.[17] ($< x > \approx 1.08 \pm 0.02$ for the cut $Q^2 \geq 3$ GeV^2).

Table 1: The values of $\alpha_s(M_Z)$ obtained in the analysis of different data sets. NDP is total number of data points, experimental error (exp) includes statistical and systematical uncertainties, (RS) is the shift due to the change of QCD renormalization scale from Q^2 to $4Q^2$.

Analysed data set	NDP	$\alpha_s(M_Z)$
SLAC-BCDMS-NMC ($0.3 \leq x \leq 0.75$)	1243	0.1170 ± 0.0021(exp)
SLAC-BCDMS-NMC ($0.3 \leq x \leq 0.75$, Fermi motion correction [12] (FMC) on)	1243	0.1190 ± 0.0020(exp)
SLAC-BCDMS-NMC ($x \geq 0.3$, FMC on)	1348	0.1197 ± 0.0019(exp)
SLAC-BCDMS-NMC (no x-cut, FMC on)	2541	0.1190 ± 0.0012(exp)$\pm$ $+0.0028$(RS)
SLAC-BCDMS-NMC (no x-cut, $Q^2 > 2.5$ GeV^2, FMC on)	2083	0.1170 ± 0.0019(exp)
SLAC-BCDMS-NMC-E665[13]-H1[14]-ZEUS[15] (no x-cut, $Q^2 > 2.5$ GeV^2, FMC on)	2512	0.1166 ± 0.0016 (exp)

Table 2: The effect of various theoretical uncertainties on the value of $\alpha_s(M_Z)$.

Source of uncertainty	$\Delta\alpha_s(M_Z)$
QCD renormalization scale variation from $1/4Q^2$ to $4Q^2$	$-0.0022, +0.0028$
The change of matching scale of heavy quark threshold from m_Q^2 to $6.5m_Q^2$(c.f. Ref.[16])	–0.0020
The change of c-quark mass on ±0.25 GeV	±0.0002
The change of strange sea suppression factor on ±0.1	±0.0001

The fitted values of HT contributions to the proton structure function F_2 and nucleon structure function F_L for different choices of the QCD renormalization scale μ are given in Fig. 1. (It was adopted in the analysis that HT contributions to the proton and neutron structure functions F_L are equal, since data cannot discriminate between them). The visible dependence of $H_2(x)$ on μ at small x can be considered as an indication that in this region HT contribution to F_2 absorbs NNLO QCD corrections. The indication on interplay between HT contribution to the structure function F_3 and NNLO corrections was obtained in the NLO QCD analysis

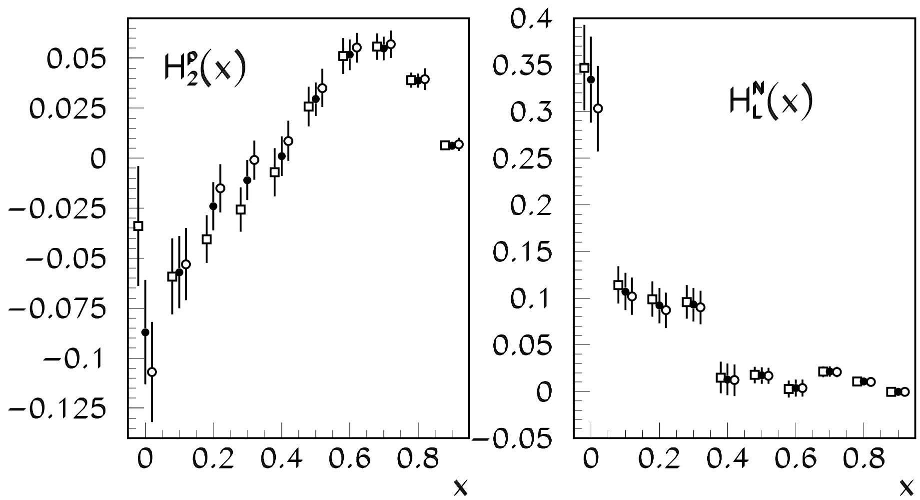

Figure 1: The fitted values of $H_2^p(x)$ and $H_L^N(x)$ for different choices of the QCD renormalization scale μ. Full circles correspond to $\mu = Q^2$, empty circles – to $\mu = 4Q^2$, squares – to $\mu = Q^2/4$

of neutrino data [18]; this interplay was also directly demonstrated in the earlier NNLO QCD analysis of Ref.[19]. At the same time for $H_2(x)$ at largest x and for $H_L(x)$ this dependence is not so significant. It is worth to note that in the fit with simultaneous extraction of α_s and HT contribution the dependence of the α_s value on μ is weaker, than in the fit with HT fixed since HT are readjusted with the change of μ; see in this connection Fig. 3 of Ref.[20]. In particular, due to this effect our value of the RS uncertainty on $\alpha_s(M_Z)$ is less than it was obtained in Ref.[17]. At the same time due to the large correlation between α_s and HT contribution to F_2 the α_s error increases as compared to the fit with HT fixed and hence one can say that some part of the RS error on α_s obtained in the fit with HT released is included in the total experimental error.

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